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CULTURAL PRACTICES in the BEARING APPLE ORCHARD

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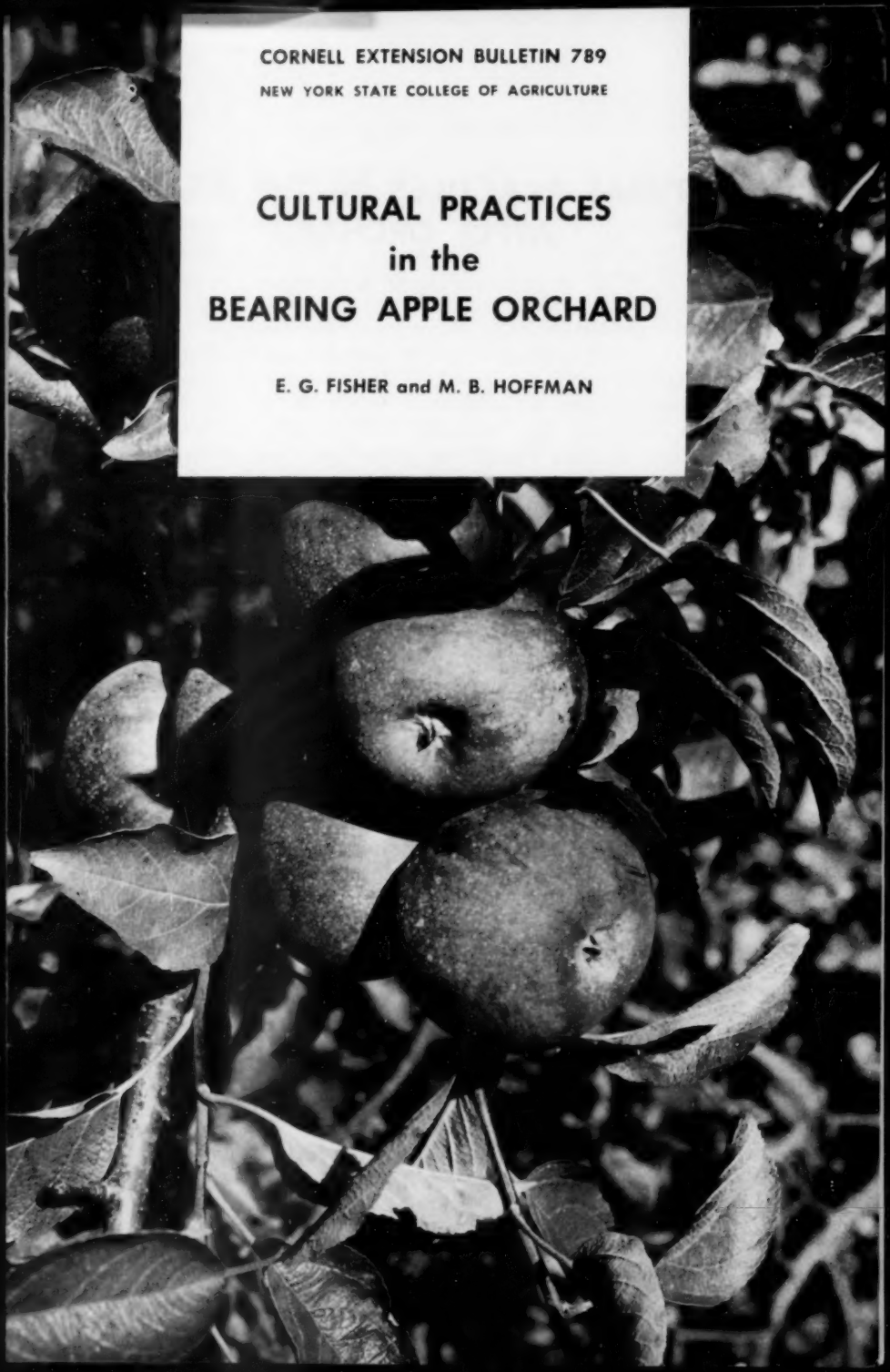


CULTURAL PRACTICES IN THE BEARING APPLE ORCHARD

E. G. Fisher and M. B. Hoffman

Apple production is the leading fruit enterprise in New York State, with a crop yield of 15 to 16 million bushels annually. Fluctuations in yield from year to year are caused mainly by weather. Because of climatic conditions, plantings are confined to three rather distinct districts: the western New York fruit belt along Lake Ontario, the Hudson River Valley area extending from Albany to New York City, and the Champlain Valley section confined to Clinton and Essex counties.

Before World War II, about 40 percent of the apples grown in the state were processed; the remainder was packed for the fresh fruit market. That portion of the crop going into processing channels has been larger from the western New York section than from the Hudson and Champlain Valley areas.

On present-day markets, apples are competing with more kinds of fruits, both fresh and processed, than ever before. Therefore, fruit quality has become increasingly important, and bearing orchards must produce high yields of good quality fruit if they are to be successful. Cultural practices for bearing orchards are discussed here from this standpoint.

THE ENVIRONMENT

Cultural practices suggested in this bulletin are designed either to modify the environment or to help the tree adjust to the existing environment. When a new orchard is planted, the existing environment must be considered carefully. The soil should be deep and well drained with an adequate water holding capacity. Winter temperatures must not be excessively cold for the varieties selected. Late spring frosts should not be a problem. These environmental conditions can be modified by practices such as orchard heating, soil drainage, and orchard irrigation. Under some conditions these practices can make money for the grower. Often, however, the necessity for their use places a severe economic burden upon him.

Sod management, orchard fertilization, pollination, spraying, thinning, drop control, mouse control, and pruning are environmental modifications that all growers must consider. The selection of proper practices is an economic necessity.

SOD MANAGEMENT

Clean cultivation with cover crops is usually required for peach, sour cherry, and young apple orchards, but is not the most desirable practice for mature New York apple orchards. Partial or trashy cultivation, or sod culture with supplementary nitrogen fertilization, is suggested. Additions of mulching materials under the trees—usually waste hay—can furnish part or all of the supplementary nitrogen.

Type of sod

A leguminous sod is usually impractical in mature apple orchards. Perennial legumes, such as alfalfa and ladino clover, require a large amount of light and a rather high soil calcium and pH level to maintain dominance in a sod. Relatively few mature apple orchards can satisfy these conditions. A good non-leguminous sod, however, must be maintained to preserve the fertility of the soil and prevent erosion. A mixture composed mainly of Kentucky bluegrass is usually satisfactory. Bare spots on the orchard floor may be caused by extreme soil acidity or by extreme deficiency of nitrogen. Occasionally phosphorus and/or potassium may be deficient.

Soil acidity

Well-drained soils upon which fruit trees should be planted tend naturally to be acid or low in pH. Moreover, the use of sulfur sprays or dusts over a period of years has often resulted in extreme acidity. All orchards should be limed periodically to maintain a surface soil pH of 6.0, but overliming should be avoided. With soils in the pH range of 4.0 to 4.9, three tons of lime per acre per application is not excessive. Two tons per acre per application is satisfactory on soils of pH 5.0 to 5.4, but no more than one ton per acre should be applied at any one time on soils of 5.5 or higher. Limestone applied to the sod surface will continue to increase

Figure 1. **The bare area under this twenty-four year old McIntosh apple tree was caused by extreme acidification of the soil. The cover was reestablished in these areas following liming.**

soil pH for several years. Two or three years should elapse between limestone applications.

Because magnesium deficiency is often a problem on acid soils, dolomitic limestone (10 percent to 20 percent MgO) generally should be used. Dolomitic limestone is often not so finely ground as high calcium limestone, and may be slower to correct soil acidity. The need for magnesium in the liming program can be determined by soil and leaf analysis.

Bare spots caused by sulfur sprays are usually most evident under the branches (figure 1). Soil acidity is usually higher (lower pH) under the tree than in the middle of the row. For this reason, the rate of limestone application should be heavier under the trees than in the middle of the row.

Soil fertility

Lack of nitrogen limits grass growth mostly in light, very unfertile soils. Bare spots caused by a lack of nitrogen are usually between the trees. Many New York orchards should receive an overall broadcast fertilizer application every other year. A soil analysis will help determine the type of fertilizer to apply. If only nitrogen is needed, ammonium nitrate at the rate of 75 pounds per acre will improve grass growth. If phosphorus and potassium are deficient, a 10–10–10 complete fertilizer at the rate of about 250 pounds per acre can substitute for the ammonium nitrate.

Mowing and weed control

A vigorous orchard sod should be mowed several times during the growing season. This is especially important in dry years and if the soil is at all restricted in rooting depth. Until recently, the only tool available for mowing was the cutter bar, which required grass height of a foot or more for proper mowing. Perhaps for this reason, the practice developed of mowing only once during the growing season. Many orchards will respond to more frequent mowing, particularly in the spring and early summer, and during dry periods. This is now possible with the rotary type mower.

Any extremely vigorous ground cover under the tree is undesirable. Quackgrass, poison ivy, goldenrod, milkweed, and wild carrot often grow excessively under tree limbs where they cannot be removed easily. A completely weed-free area within three feet of the tree trunk aids in mouse control. Herbicides are now available that can suppress and eliminate weed growth in the orchard. Use no herbicide, however, until you have information regarding its label clearance for use in bearing orchards.

NITROGEN FERTILIZATION

Amount

The reputation for growing hard, red, late-keeping, top condition apples is the best possible advertisement for New York growers. Although nitrogen fertilization increases yield, it decreases firmness of flesh and red color of skin. Therefore, growers of both fresh and processing fruits must sacrifice yield to obtain top quality.

Orchards vary in their natural fertility and need for supplemental nitrogen. A leaf nitrogen level of about 1.7 percent in August-collected samples is associated with the best fruit quality consistent with the maintenance of annual bearing. Rates of application of ammonium nitrate suggested for trial are given in table 1. Some soils will require heavier rates and a few orchards will do well with no additional nitrogen.

The best indication of the success of a nitrogen fertilizer program is crop size and fruit quality. Crop size should not fluctuate widely from year to year, and the average mature orchard should yield more than 300 picked bushels per acre. *In favorable years* at least 75 percent of the fruit should have better than 50 percent of the surface covered with solid red color. Many factors other than nutrition influence color development, and even red color is not always associated with development of best fruit quality or proper harvest maturity. The best indicator is fruit firmness and freedom from storage disorders after a period of storage. Development of red color may be helpful but is not always the best indication of the proper rate of nitrogen fertilization.

Leaf color and terminal growth are tree responses that can aid in adjusting the nitrogen program. By mid-season, leaf color should be lightly tinged with yellow, and terminal growth should approach five to eight inches in length. Considerable tree variation is often noted in orchards maintained at a borderline nitrogen level, with each tree needing individual attention. At harvest time, those trees that require more or less than the average rate of nitrogen fertilization should be marked.

Table 1. Rates of ammonium nitrate application suggested as a trial in mature McIntosh apple orchards

Bearing capacity of tree	Ammonium nitrate
Bushels	*Pounds*
Less than 10	1.0 to 2.0
10 to 20	2.0 to 3.0
More than 20	3.0 to 3.5

The grower of fresh fruit may find these suggestions valuable. The grower of processing fruit may find slightly higher nitrogen levels than those suggested to be profitable. New York can afford to process only top quality, firm, high-soluble-solids apples of the best adapted varieties.

Kind

Nitrogen fertilizers that can be most commonly purchased are:

	Percent Nitrogen
Urea	45
Ammonium nitrate	33
Sodium nitrate	16
10–10–10	10

The complete fertilizer (10–10–10) is the most expensive and is suggested only where soil and leaf analysis indicate the need for additional or maintenance applications of phosphorus and potassium. Nitrogen in a complete fertilizer is generally in the form of ammonia. The continued use of sodium nitrate over a period of years can affect soil structure adversely. Ammonium nitrate and urea are the least expensive of the available forms and are satisfactory for orchard use. Theoretically, the nitrate form of nitrogen should be more readily available to tree roots than the ammonia form—a difference that tends to be most pronounced on acid soils. However, few experiments with apple trees have shown large differences between nitrate and ammonium nitrogen as long as the fertilizer was applied in late fall or very early spring, and the trees were adequately supplied with other nutrients.

Time of application

Early spring, a month or more before bloom, is probably the best time to apply nitrogen in apple orchards. Occasional experiments have indicated a better response from late fall than from spring application. This may be particularly true if a heavy grass and weed growth develops under the trees and the spring application is delayed until late in the season. In this case, grass and weeds can absorb much of the fertilizer intended for the tree. Nitrogen applications in October or early November can increase susceptibility to a winter injury that causes trunk bark to split and loosen, but applications delayed until late November or December have caused no increase in winter injury.

Nitrogen fertilizer should not be applied to the soil during the growing season, because this practice frequently results in reduced fruit color. If leaf nitrogen appears deficient in June, a foliage application of urea can be made immediately with little adverse effect on fruit color in September.

Method of application

Fertilizer can be broadcast by hand under the spread of the branches or applied with an end-gate spreader. Placement of the fertilizer by hand usually requires smaller rates of application than it does by machine; therefore, the cost of the increased amount of fertilizer required with machine application can offset any reduction in labor cost. Also, adjustment of the nitrogen level can be more accurate with hand application. The quickest method to apply fertilizer by hand on large trees is to circle the trunk, throwing the fertilizer toward the drip of the branches.

Liquid fertilizers and machines that increase the speed of application are now available. Some of the machines measure the rate of application accurately. With such equipment, however, adjustment cannot be made easily for individual tree vigor. Liquid nitrogen is usually a combination of ammonium nitrate and urea, the effectiveness of which should be similar to pelleted formulations of equal rates and materials. The use of liquid ammonia that must be chiseled into the soil is not desirable in sod orchards.

FERTILIZATION WITH OTHER MATERIALS

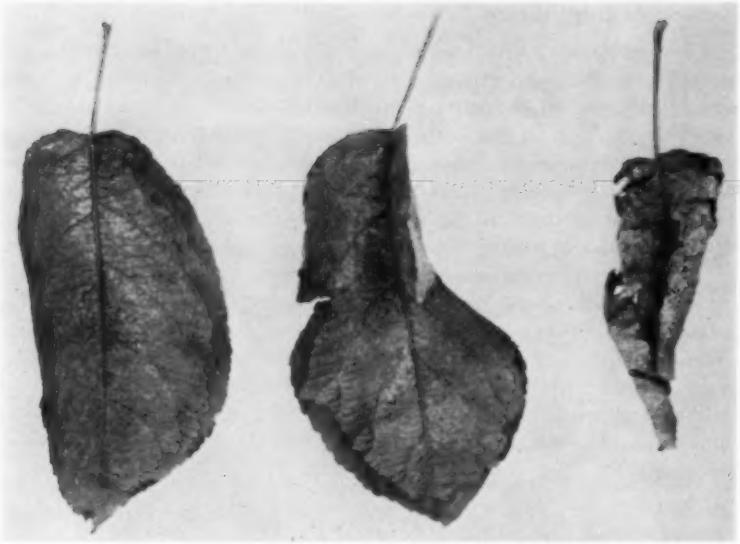
Potassium

Symptoms. Many New York orchards have recently shown response to potassium fertilization. Soil acidification from sulfur sprays has undoubtedly been partly responsible for the loss of potassium, as well as calcium and magnesium bases, from orchard soils. When, as in many orchards, both potassium and magnesium are low, leaf deficiency symptoms may not be apparent. Poor growth and small leaf size are the most apparent symptoms.

Leaf scorch is a symptom of potassium deficiency (figure 3). It may appear first on the older leaves and progress to the younger ones. Sometimes only the first leaves to develop in the spring are affected. The scorch proceeds inward from the margin and may cause the leaf to fold or roll toward the upper surface, or to fray or tatter. These symptoms are similar to those caused by injury from some spray materials, but leaves that are low in potassium are susceptible to spray injury.

Severe potassium deficiency can result in short and thin terminal growth that is susceptible to winter injury. Yield can be reduced and the fruit may be small and poorly colored.

Potassium deficiency is more likely to occur on old orchard sites, on sandy or gravelly soils, on poorly drained soils, and soils high in pH, calcium, and magnesium.



Photograph by W. Reuther

Figure 2. **These McIntosh apple leaves show, from left to right, successively worse injury from potassium deficiency scorch. Symptoms are sometimes hard to distinguish from spray injuries.**

Figure 3. **These McIntosh apple leaves show three stages of injury from magnesium deficiency blotch. The interveinal yellowing on the leaf at left often precedes the death and browning of these areas.**

Control. Any severe tendency toward magnesium deficiency should be corrected before potassium fertilizer is applied. A leaf-analysis service is available for New York growers to help determine the need for and dangers from potassium fertilization.

Mulch is an excellent source of potassium, but severe potassium deficiency is corrected best with muriate or sulfate of potash. Generally, a mature tree should receive no more than five pounds of muriate of potash in any one application and no more than ten pounds in a three-year period. Sulfate of potash magnesia is a better choice if leaf magnesium is borderline. A complete fertilizer (10–10–10) can occasionally be used as a maintenance or insurance fertilizer application.

Magnesium

Symptoms. Soil acidification from sulfur sprays and acid fertilizers has been the most common cause of magnesium deficiency problems. Potassium fertilization of magnesium deficient trees occasionally has increased the severity of the problem. A leaf and soil analysis can determine the need for magnesium fertilization.

Leaf injury caused by magnesium deficiency appears first on the older leaves and progresses to the younger ones. Death in the leaves tends to occur between the veins (figure 4) and is usually preceded by yellowing or whitening. Severely affected leaves will drop before fruit harvest.

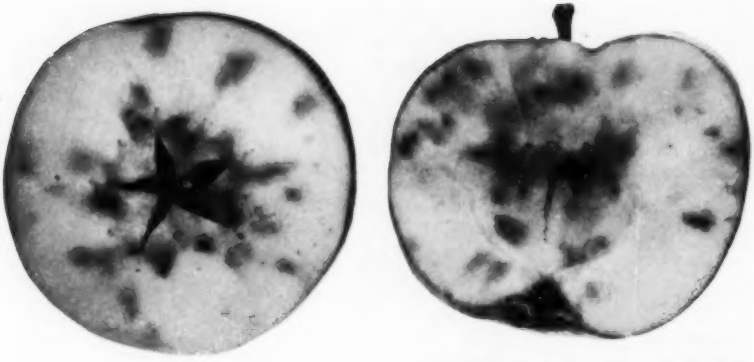
Other symptoms of magnesium deficiency are an increased preharvest fruit drop, reduced fruit size, and the presence of bare areas on the soil under the trees. If the deficiency is severe, tree vigor and fruit yield are both reduced.

Control. All orchard soils should receive periodic limestone applications to maintain a surface soil pH of 6.0. Further details for orchard liming are described in the discussion on maintenance of the sod. Limestone applications may take four to six years to effect control. If symptoms or leaf analysis indicate a severe problem, however, soil application of kieserite or foliage sprays of epsom salts will speed deficiency control. The rate of application suggested for kieserite is 10 to 20 pounds per mature tree. Three sprays of epsom salts at 15 pounds per 100 gallons are suggested for severely deficient apple trees. The sprays should be applied dilute and should not be combined with a lead arsenate insecticide spray.

Boron[1]

Symptoms. Boron deficiency can cause four symptoms in the apple: internal cork, external cork in the fruit, die back and rosette in the twigs.

[1]Prepared in cooperation with A. B. Burrell, Professor Emeritus, New York State College of Agriculture, Cornell University.



Photograph by Dr. A. B. Burrell

Figure 4. **Internal cork, developed in late summer, is the most common boron-deficiency symptom in apples. The variety shown is Cortland at harvest time.**

Internal cork of the fruit is the only symptom common in New York. Boron deficiency also may cause an unusually severe pre-harvest fruit drop. Losses from boron deficiency are most common in the Hudson and Champlain Valleys but occasionally occur in all fruit areas of the state, especially in dry summers. The McIntosh and McIntosh parentage varieties often show more loss than do other varieties.

Control. Any orchard that has ever shown boron deficiency should receive a boron soil treatment every third year or an annual boron spray. Young trees that have had only a single treatment on the soil may require another boron application after two years because of a great increase in bearing surface. Use either fertilizer borate, high grade, or agricultural pentahydrate borax on the soil. The rates are as follows:

Approximate trunk diameter 1 foot above ground	Amount of fertilizer-grade borax
3½ inches	2 ounces
5 inches	4 ounces
7 inches	6 ounces
10 inches	8 ounces
14 inches	8–12 ounces
15 inches	12–16 ounces

The borax should be applied in a narrow (4- to 10-inch) ring, a foot or two in from the tips of the branches in the early spring.

Most growers now prefer to substitute annual boron sprays for application of borax to the soil. Highly soluble preparations consisting of sodium pentaborate are sold as Solubor and Boro Spray. Either may be added to one or two regular sprays, one to three weeks after petal fall.

Average-sized bearing trees should receive four pounds per acre each year, preferably two pounds per acre in each of two sprays. Thus if 550 gallons of dilute spray are applied per acre, about 3/8 pound of sodium pentaborate per 100 gallons in two sprays would make four pounds per acre. With 2X sprays the results would be similar, with 275 gallons per acre containing 3/4 pound of sodium pentaborate per 100 gallons. In counties where boron deficiency has occurred, an orchard owner who has not suffered losses might want to consider an annual pentaborate spray at two pounds per acre.

A sodium pentaborate material is preferable, if available. Fertilizer grades of borax often contain grit, and never should be used in a spray machine.

Boron does not move freely from one branch to another after it has been absorbed by leaves. Consequently, boron sprays should be as thorough as those required to control the more difficult pests, such as mites.

SUPPLEMENTARY MULCHING

Many commercial apple growers use waste hay and other organic refuse as mulches for their trees. These materials have value not only as fertilizers but as deterrents to erosion and water loss. The value of mulching is greatest on shallow, eroded hilltops where water may become deficient in dry years. Its beneficial effects are less evident on deep, well-drained soils containing sufficient loam or clay for good water-holding capacity.

Mulching materials vary considerably in their nitrogen content; straw is low, alfalfa hay is high. In the beginning of a straw mulching program, nitrogen fertilization is needed—often at rates higher than if the material were not applied. After about four years of a heavy mulching program, the nitrogen will be released from the organic matter in which it has accumulated. A high-nitrogen mulch such as alfalfa or pea vine hay may release large amounts of available nitrogen the first year of application. Because it is difficult to tell how much nitrogen is being added by a mulch, and at what rate nitrogen will be released for plant growth, adjusting the nitrogen level of the trees on a heavy mulching program is difficult.

The best way to prevent the problem created by over-mulching is to make applications light enough to allow the grass to grow readily through

the mulch. With this rate of mulching, some nitrogen fertilization may be needed; the amount should be gauged by the behavior of the trees.

The problems of mouse damage and the possibilities of a fire hazard are increased by a mulch program.

If the cost for a mulching program is much greater than for sod culture with nitrogen fertilization, its use may be questioned. If the mulch is readily available and can be applied cheaply, it can be used as a major means of fertilization for apple trees.

IRRIGATION[2]

Interest in irrigation of apple trees in the Northeast varies from year to year. Beginning with the dry years of the mid-thirties and continuing to the present, commercial apple growers have shown interest in supplemental irrigation in inverse proportion to current rainfall. Recently, the very low prices received for small apples of some varieties, and the tremendous savings in labor made possible by the development of lightweight, portable irrigation pipe have increased interest in irrigation.

Economic considerations

Under certain conditions, irrigation of apple trees can be very profitable, but the success of the practice is dependent on a number of factors that must be carefully evaluated by the grower before irrigation is attempted. The most important and the most obvious factor that affects the response to irrigation is the amount and distribution of rainfall during the growing season. If rainfall is adequate for optimum fruit growth, then irrigation will be ineffective, regardless of other conditions.

In dry years, with some varieties on some soils, irrigation has been very beneficial, but in the same year, with other varieties on other soils, the results have been disappointing. Apple trees are most likely to show a measurable response to irrigation on very coarse soils with a low water-holding capacity, or on very shallow soils where root growth is restricted by underlying rock ledges or by poor subsoil drainage. Even in the driest years, irrigation of apples growing on a deep, well-drained loam or silt loam soil might be unprofitable. Although a measurable increase in fruit size frequently can be demonstrated in such circumstances, this improvement in fruit size is usually insufficient to pay the cost of irrigation.

Irrigation of apples is most profitable when the variety is one with a fruit size problem and one with a substantial price differential between sizes. The increase in yield that can be obtained by irrigation is frequently

[2]Prepared by Dr. C. G. Forshey, Hudson Valley Fruit Investigation Laboratory, New York State Agricultural Experiment Station, Poughkeepsie, New York.

not enough to pay the cost of irrigation; the unit price of the fruit must also be increased if the operation is to be profitable. The varieties that can be most profitably irrigated under New York conditions are the early maturing varieties such as Lodi and Early McIntosh, where size is of major importance, and varieties such as Delicious and Golden Delicious, which now command a premium for the larger sizes on the fresh fruit market.

Water supply

One factor that must be carefully studied when orchard irrigation is considered is the water supply. To apply one inch of water to an acre, 27,000 gallons of water are required, and it may take 240,000 gallons of water, or more, to irrigate an acre through a very dry growing season. If available water is not sufficient to supply this amount for every acre to be irrigated, then irrigation should not be attempted. Insufficient water applied irregularly may cost as much as systematic irrigation without increasing the value of the crop.

Equipment

If the combination of soil conditions and varieties being grown indicate that irrigation might be profitable, and a satisfactory source of water is available or can be easily developed, the purchase of irrigation equipment can be a good investment. At the present time, portable aluminum pipe with low angle sprinklers is the most efficient, most versatile, and most labor-saving type of equipment. For a commercial operation, sufficient pipe and sprinklers to cover at least two acres at a time should be purchased. In most orchards, six-inch pipe is used for the main lines and four-inch pipe is used for the laterals. The pump should be of a capacity to deliver water in the orchard with all sprinklers operating at a rate of not less than ¾ inch per hour. A satisfactory system for commercial use, at current prices, costs about $8500.

Some device for measuring soil moisture should also be purchased. Several types of moisture meters are now available and most cost less than $100. Such a meter is desirable for two reasons: it insures proper timing of irrigations, and it enables the operator to determine exactly how much water must be applied at one time for optimum results. An application of water that does not raise the moisture level of the soil to field capacity in the area of greatest root density is not efficient. In most instances, applications of less than three inches of water at a time are inadequate. Studies in the Hudson Valley have indicated that water should be applied frequently enough to maintain a soil moisture level of 25 percent of the available soil moisture range at a depth that includes

½ to ⅔ of the root system. In well-drained soils, the appropriate depth may be 18 to 24 inches and in shallow soils it may be as little as 12 inches. The proper depth at which to measure soil moisture can be determined only by examination of the root systems of trees growing in the particular soil under consideration. The maintenance of the 25 percent moisture level throughout the entire growing season is exceedingly important, for experimental results have shown that fruit growth is retarded when soil moisture drops below this level. Because the apple fruit grows slowly but steadily from fruit set to harvest and does not exhibit a period of accelerated growth as the stone fruits do, any loss in growth from a deficiency of water will be permanent and cannot be compensated for by increased irrigation later in the season. If maximum fruit size is to be obtained, soil moisture must be maintained at or above 25 percent of the available range in the area of greatest root density throughout the entire growing season.

Conclusions

Irrigation equipment is expensive and labor requirements for the operation are high. This unfortunate combination makes irrigation a costly practice. Cost account studies indicate that the price of irrigating apple orchards is within the range of $46 to $75 per acre, depending on the amount of water applied and the efficiency of the irrigation system. In a dry year, however, supplemental irrigation properly applied to a responsive variety on a droughty soil may cover such costs and increase the net return by $200 per acre or more.

One point that cannot be overlooked is the fact that irrigation will not overcome deficiencies in other aspects of orchard management. If the trees are not well pruned, properly fertilized, and the fruit is not adequately thinned, response to irrigation will be disappointing and the purchase of irrigation equipment will be an unwise investment.

ORCHARD HEATING

The value of heating to prevent frost damage in New York orchards is limited by economic considerations. If New York orchards are located in areas with adequate air drainage or protected by large bodies of water, spring frost is not a sufficient problem to justify the expense of orchard heating.

A few orchards in New York are not so ideally located. If soil, variety, and other factors are otherwise satisfactory, some consideration might be given to orchard heating. The cheapest method of heating is to burn old tires, gallon or large-sized cans filled with wood shavings and oil. These methods are relatively ineffective but a few New York orchards have

shown probable increases in fruit set if the number of fires per acre was adequate and the temperature increase required was only a few degrees.

In 1950, in citrus orchards with 50 orchard heaters per acre operating 20 hours per year, the annual operating cost was about $55 and the fixed costs about $15. The annual total cost was then $70 per acre. Experience suggests that orchard heaters are more effective, and fewer numbers will suffice when used as a supplement to wind machines. Cost studies (1950) indicated that the use of a wind machine for 20 hours and 18 heaters per acre for 10 hours per year resulted in an average annual cost per acre of more than $50. Obviously, an orchard that is protected with the most efficient equipment against frost damage must show an average annual increase in net profits of $50 to $100 per acre per year to justify the expense.

Should the grower decide that the results can justify the expense or that a cheaper method of orchard heating is desirable, the fruit agent can give suggestions on heater placement.

POLLINATION

The value of cross-pollination for practically all apple varieties is well recognized. Without adequate cross-pollination, good yields are impossible. From the grower's standpoint, two aspects of the pollination problem are important: a supply of suitable pollen for each variety, and the distribution of this pollen by insects.

Usually, provisions for cross-pollination are made when the trees are planted, but it is always difficult to decide how far apart the pollinizers should be set. No planting is adapted to all conditions. If warm, sunny weather prevails during bloom and if bee population is high, enough cross-pollination could be obtained with a minimum number of pollinizers; that is, one tree of the pollinizer to every eight trees of the main variety. On the other hand, with little favorable weather for bee flight during bloom, trees of cross-compatible varieties need to be much closer together, perhaps row for row, to obtain a satisfactory set.

In many years the weather is cool, cloudy, and rainy in New York fruit areas during apple bloom. Weather records show that this happens more often in western New York than in the Hudson Valley. Considering the frequency of such unfavorable weather during bloom, production in many mature blocks of apples probably could be increased by providing for more cross-pollination.

Effective distances for pollinizers

Because weather is involved, it is impossible to suggest definite distances over which the pollinizer will be effective. The distance depends

upon the number of insects present and the length of time that they have to work. About all the grower can do is to provide enough pollinizers and enough bees to assure satisfactory cross-pollination under the least favorable weather conditions. In western New York, pollinizers throughout every third row would seem to be justified; in other fruit areas of the state, pollinizers in every fourth orchard row should be enough.

Top-working to provide pollinizers

If there is evidence of a lack of cross-pollination, top-working additional trees to a suitable pollinizer might be tried. In bearing orchards, top-working trees for pollination temporarily reduces the bearing surface. In blocks, however, where more provision for cross-pollination is needed, this is the quickest way to remedy the situation permanently and it should be done in a way to get an adequate supply of pollen into the orchard in the shortest time. To do this, it is better to top-work the entire tree rather than the small branches or shaded parts, because setting a few grafts on such branches usually produces poor scion growth unless special attention is given to pruning and subsequent care. In top-working trees up to 20 years of age, enough of the main limbs needed to form a new head should be grafted the first year (figure 6). Loss of bearing surface

Photograph by Dr. L. H. MacDaniels

Figure 5. **McIntosh tree topworked to Cortland, which serves as a pollinizer. The grafts, five years old, have made good growth and are producing bloom.**

may be minimized by grafting far enough out on the limbs to leave about ⅓ of the lower part of the tree intact. This can be pruned away as the grafts develop. With smaller trees, grafts can be set closer to the trunk.

Bouquets in the orchard

To provide a makeshift source of pollen until grafts of top-worked trees produce bloom, the grower may bring blossoming branches of a satisfactory pollinizer into the orchard. Where such bouquets and bees have been provided and under favorable weather conditions, fruit set has been increased in orchards that had not previously yielded well. This practice, however, has definite limitations in seasons unfavorable for insect flight. Under such circumstances the set of fruit is not materially affected beyond the trees in which the bouquets are placed; to obtain satisfactory results, bouquets should be placed in all trees.

The best location for bouquets depends upon the bees' habits in visiting flowers for nectar or pollen. Individual bees usually work for a prolonged period in one place, or in a relatively small area, and go from the hive to that place and return without stops at other trees. For the best distribution of pollen, the bouquets should be placed in or near the tree to be pollinated.

It should be noted that the effectiveness of the bouquets is proportional to their size and whether insects visit the bouquets or not is largely a

Photograph by Dr. L. H. MacDaniels

Figure 6. **A bouquet for cross-pollination is in a drum of water to keep it fresh.**

matter of chance. The larger the mass of bloom, however, the greater are the chances of insect visits. Branches from one to three inches in diameter, of a good pollen variety, should be used for this purpose. The need for such branches should be anticipated by delaying until bloom time the pruning of the trees that are to furnish the bouquets. The branches can then be placed with their cut ends in water in any available container, such as discarded spray-material drums (figure 7). A good method is to place the water containers under the low limbs of trees to be pollinated and to force the bouquet in among the branches. This keeps the bouquet from blowing over. A large bouquet that would fill a 50-gallon drum would attract insects and be effective in cross-pollination when placed between closely adjacent trees. The bouquets should be brought into the orchard as soon as the variety to be pollinated is in bloom. Growers should try to keep the bouquets fresh throughout the bloom period by adding water to the containers every other day or whenever it is needed.

BEES IN THE ORCHARD[3]

Many kinds of insects visit apple blossoms and transfer pollen from one variety to another. The honey bee, credited with about 90 percent of the pollen transfer in orchards, is the only valuable cross-pollinating agent that can be concentrated in sufficient numbers and managed by the orchardist. Bumble bees are valuable for this purpose because they fly at somewhat lower temperatures and in stronger winds than honeybees, but bumble bees are not plentiful enough in the spring and they cannot be efficiently increased and moved about. Solitary bees, too, seldom appear in any appreciable numbers except in orchards near much wasteland. Flies and other insects contribute little to cross-pollination. Unfortunately, all of these insects need approximately the same favorable weather conditions for flight as does the honeybee, and since they are relatively few in number, are unimportant and cannot be depended upon to set commercial crops of fruit.

The grower may either own honeybees or rent them from a beekeeper, but because of the specialized nature of beekeeping, renting is advisable. Bees require special attention during certain periods of the year, otherwise they will die or become so weak that they are practically worthless at pollination time. To be of maximum value for pollination, the colonies must be strong and contain a large number of young bees in the spring. This is accomplished by placing into winter quarters only strong colonies of young bees adequately supplied with good food and protected from the

[3]Prepared by E. J. Dyce, Professor of Apiculture, New York State College of Agriculture, Cornell University.

Figure 7. **Bees placed at the corner of an orchard for cross-pollination. The woodlot protects the hives from prevailing winds.**

wind and cold. To ensure enough young bees in the fall, as well as in the spring, it is necessary each summer to requeen all colonies that have failing queens.

Because of the insecticides now used to control injurious insects on fruit trees, honeybees are no longer able to survive or maintain their populations if left in or near orchards the year round. The colonies must be kept in permanent locations at least two or three miles away from the orchards and moved into the orchards only for the blossoming period. Before the bees are moved into the orchards in the spring, they require considerable attention and care. If the colonies are too weak in bees they will not do an efficient job of pollination and if they are too strong they may swarm. If they do not have enough food they may starve, and if they have too much honey and conditions are favorable for nectar secretion they may become crowded and swarm. It is a costly procedure to feed colonies or control swarming when the bees are spread throughout the orchards. The best plan is to equalize all the colonies before they are moved into the orchards even though it is a laborious task.

The number of colonies needed in an orchard depends upon weather conditions and upon the strength of the colonies. Honeybees are cold-blooded and their work is limited when it is cold and windy. They seldom fly at temperatures below 55° F. They take short flights at 65° F. but long

flights are not taken until temperatures have reached 70° F. or more. A wind of 15 miles per hour greatly reduces flight and at 25 miles per hour it is practically stopped. Thus strong colonies are more economical because they fly at lower temperatures and have more field bees to visit the blossoms. During a cold bloom period, one strong colony could conceivably distribute more pollen than a dozen weak ones. Experience in several states indicates that one colony of medium-strength per acre is satisfactory. Such a colony would normally have broods in four or five frames and contain from 15,000 to 20,000 bees. When good weather prevails, one strong colony consisting of 30,000 or more bees should be able to pollinate three or four acres of orchard.

In the spring, honeybees frequently gather water to dilute the concentrated reserve supply of honey that they carry over during the winter in their hives. During cold, wet springs, when the bees are in the orchard, they prefer to gather moisture from decaying vegetation located in the sunlight underneath or near trees where the water is warmer and more attractive. During hot, dry periods the bees frequently gather water from holes near water tanks or from ruts made by the spray rigs.

Arsenic heads the list of poisons that have caused serious losses to honeybees. One application of arsenate of lead used before bloom will contaminate most of the water that the bees are likely to pick up in the orchard. For this reason, fruit growers should not use arsenate of lead or other insecticides of high, long-lasting toxicity in the spring program until after the bees are removed from the orchards. Honeybees often work blossoms after most of the petals have fallen as well as terminal blossoms that are late in opening. In McIntosh trees, the bees usually work the blossoms more ardently after the petals have fallen than when the trees are in full bloom. All colonies should therefore be removed from orchards before the calyx spray is applied or the poison will be carried into the hive on the pollen and cause serious bee losses.

Flowers such as dandelion and yellow rocket yield considerable nectar and pollen and are frequently more attractive to bees than fruit blossoms. For best pollination results, these weeds should be destroyed in and around the orchards. They not only attract some bees away from the fruit trees but, if insecticides settle on them, some bees might be poisoned. If there is a great deal of dandelion and yellow rocket present and no attempt is made to discourage their growth, bees should not be moved into the orchards until the fruit blossoms are ready for pollination. This precaution will reduce the number of bees starting to work on these plants; once bees start working one kind of flower they seldom switch to another. This habit has its advantages but it also has its disadvantages when competing flowers are present in an orchard.

Insecticides are occasionally divided into three groups of high, medium, and low toxicity to bees. In the high toxicity group are usually found lead arsenate, calcium arsenate, parathion, dieldrin, chlordane, aldrin, lindane, Sevin, Guthion, malathion, Phosdrin, and Tepp.

In the group of medium toxicity are Trithion, Tedion, Thiodan, DDD (TDE), Perthane, and Endrin.

In the group of low toxicity are DDT, methoxychlor, ovex, Genite, Ethion, Mitox, Toxaphene, Tetram, and demeton.

The entire problem of providing adequate orchard pollination calls for careful study and cooperation. When a serious bee poisoning problem arises it can usually be solved to the satisfaction of the fruit grower as well as the beekeeper.

Artificial pollination

Hand-pollination is profitable for any self-unfruitful variety if the weather during bloom is unfavorable for the activity of bees. Pending the time that adequate provisions for cross-pollination can be made by interplanting or top-working, hand-pollination is a valuable supplement to bouquets as an emergency measure for solid blocks of such varieties as McIntosh, Delicious, and Northern Spy.

Only pollen from those varieties that furnish an abundance of this viable material should be used. Among these are Delicious, Hubbardston, Duchess, Twenty Ounce, Jonathan, Ben Davis, and Northern Spy. Wealthy has good pollen, but it is not produced in very large quantities. Baldwin, Rhode Island Greening, and Gravenstein are worthless as sources of pollen. Care should always be taken to gather pollen of some variety other than the one to be pollinated. If enough pollen of one variety cannot be obtained, it can be combined with that of any other desirable variety; that is, a mixture of Duchess and Delicious pollen would be satisfactory for Northern Spy trees.

One of the most practical ways to collect pollen in quantity is to gather the blossoms when they are in the balloon stage or just before the flowers open. Blossoms in this condition can be picked rapidly. A convenient method is to use a fruit-picking bucket, slung from the shoulders by straps so the flowers can be picked with both hands.

There are several ways to remove the anthers or pollen-bearing organs from the flowers. The anthers can be pulled off with the petals by breaking or twisting the unopened flower with the fingers. A faster and very effective way is to dump a handful of flowers onto a screen, with about eight meshes to the inch, and gently rub the flowers back and forth so the anthers are broken off and fall through the screen into a suitable receptacle. With either of these methods, considerable quantities of torn petals

and other flower tissues are mixed with anthers. The anthers can then be easily cleaned of this "chaff" through a small sieve with a hand crank and agitator such as those used to sift flour.

The green anthers should then be spread out thinly on waxed or glazed paper to ripen. Newspaper is not satisfactory because it is too fuzzy and much of the pollen adheres to the surface. The anthers should be ripened in a sunlit window. Mild heat may be applied if sunlight is not available. After about 24 hours, the anthers should have ripened and split so the pollen appears as powdery yellow dust.

The dried anthers shedding the pollen may be stored in small, ½- to one-ounce glass bottles. Pollen is a living material; it respires and, if stored in large quantities or under warm or moist conditions, heats and loses its viability. It should be kept cool and dry. If the bottles are stoppered, cotton plugs should be used. Storing the bottles in a desiccator held at about 36° F. is ideal. If such equipment is not available, the bottles should be placed where these conditions will be most nearly met. Never, under ordinary conditions, is it advisable to keep pollen for more than a week from the time it is dried until it is used.

The small, wide-mouthed bottles commonly used for individual servings of coffee cream make excellent containers in which to carry the pollen in the orchard. A small strip of gauze sewed tightly around the neck of such a bottle and pinned with a safety pin to the operator's shirt is a convenience in getting around through the tree and decreases the chances of tipping containers and of wasting pollen.

One of the most practical ways to apply pollen is to spread it on the flower with a small camel's hair brush, with bristles about ¾-inch long and with a six-inch handle. The brush is dipped into the pollen containers so some of the powdery yellow dust adheres to the bristles, then the bristles are dabbed lightly upon the center of the apple flowers so the stigmas come in contact with them. It is necessary to pollinate only one or two flowers in every fourth or fifth cluster on a full-blossoming apple tree. Insects redistribute the pollen from the hand-pollinated clusters to other parts of tree.

The time spent on hand-pollinating a tree depends on its size. For a 20-year-old McIntosh tree capable of bearing 25 bushels of fruit, from 15 to 20 minutes per tree should be enough. About half of this time should be spent on the ground and the remainder in the top of the tree, either using a step ladder or climbing into the tree. The application of pollen to every other tree in every other row ordinarily is enough if bees have some opportunity to work. If time permits, the orchard can be gone over again to apply pollen to some of the other trees.

The problem of applying pollen in quantity with a duster or with some other types of blowers has been investigated, but no practical or effective method has been devised or tested at present. Because of the nature of apple pollen, of the problem of collecting it in large quantities, of handling and keeping it in a viable condition, and of applying it to the small stigmatic surfaces, cross-pollination lends itself best to some method of direct contact, such as through bees, other insects, or the brush method described.

Disadvantages of over-pollination

Any consideration of the provisions for cross-pollination should point out the disadvantages as well as the advantages. Some of the disadvantages of cross-pollination are obvious in mixed plantings where there are minor problems in spraying and harvesting. Such problems are reduced to a minimum, if the pollinizers are in solid rows. An excessively heavy set of fruit produced by over-pollination under favorable weather conditions is possible. For example, McIntosh and Delicious, closely interplanted, might bear such a heavy crop in a favorable year that both varieties would become biennial in their bearing habits. If this happened, chemical thinning could be employed in the heavy crop year to restore annual production. Because chemical thinning is practicable, probably the wisest procedure would be to provide sufficient cross-pollination for the more unfavorable bloom seasons. It is during such years that crops are lightest and prices are highest.

SPRAYING

Spray and dust programs for the control of insects and diseases are essential. Detailed information on timing and materials can be obtained from your county fruit agent.

Most of the spray materials used in former years reduced the efficiency of leaves in the manufacture of carbohydrates. Modern pesticides are much less harmful to the foliage. However, some of those still in use may injure foliage under certain conditions.

The amount of damage done to leaves in wet seasons with arsenate of lead when used without extra lime as a corrective is not fully appreciated by many growers. Under hot weather conditions, the wettable sulfurs of fine particle size can reduce photosynthesis by significant amounts. On the other hand, any disease or insect that destroys or damages any part of the leaf surface would tend to reduce the total amount of food that could be produced. In planning the spray program, it is necessary that the materials selected should not only be effective in controlling the

pest but should interfere little if at all with the proper functioning of the leaf. Invisible spray injury may influence the crop by reducing size, color, and quality of the fruit, and sometimes by aggravating the tendency toward alternate bearing.

Practically all orchard operations, fertilization, pruning, spraying, and thinning, may have an influence on the ability of the leaves to provide additional food. It must be recognized, however, that weather conditions may have an even greater influence than anything the grower can do to determine the rate of photosynthesis. Therefore, orchard practices should be employed to favor the development of a large leaf surface early in the season and to maintain this type of foliage throughout the summer so that it can work efficiently whenever weather conditions permit.

THINNING

The need for thinning depends on the set of fruit. When the set is heavy, thinning prevents overbearing and improves the market value of the crop. Observations and experimental evidence show clearly that fruiting is an exhaustive process. The production of flowers and fruits removes appreciable quantities of the various carbohydrate materials, nitrogenous substances, and other necessary nutrient reserves from the spurs and adjacent storage tissues of the tree. While the mere development of the bloom removes a sizable amount of these food materials, even greater quantities are used in the growth of young fruits. For this reason the growth of the vegetative portions, such as shoots and leaves, is usually less during a fruiting year than during an unproductive year.

If the set of fruit is excessive, vegetative growth will likely be reduced to a bare minimum and the differentiation of flower buds for the following crop may be largely or entirely prevented. Too heavy a set of fruit always results in a high proportion of fruit of small size and of relatively poor quality. Thinning will improve the size and quality of the crop and will help to maintain within the tree a supply of those materials necessary for annual growth and for flowering the following year.

Variety

Under most conditions, some varieties characteristically set more fruit than do others. The following are noted for their ability to overset and require thinning: Transparent, Lodi, Early McIntosh, Oldenburg, Wealthy, Macoun, Baldwin, and Golden Delicious. Under certain conditions any variety may set too heavily. This usually happens when a heavy bloom follows a light crop or a crop failure, and when favorable conditions for fruit setting prevail. Thinning is usually more profitable with

early varieties and with those that are naturally small than with late varieties or those characteristically large.

Effects on current crop

The favorable effects of thinning seem to result mainly from increasing the proportion of leaves to fruits. A set of one fruit for every 10 or 15 leaves usually results in fruits of small size, poor color, mediocre quality, and an excessive exhaustion of the tree. Reducing the set to 30 to 40 leaves per fruit markedly improves the crop and the condition of the bearing wood. Fruits are influenced by the leaves several feet from them provided no other fruits intervene. For this reason it is not necessary to break clusters if the general set over the entire fruiting area is relatively light.

When the set is heavy, the greatest benefit from thinning is the increase in size attained by the remaining fruits (figures 9 and 10). Other conditions being constant, the size at harvest time depends mainly on the number of fruits left on the tree or the leaf-fruit ratio, rather than the number removed. Of course, thinning beyond a certain leaf-fruit ratio may not materially influence size, because a point of diminishing return is gradually reached. In addition to thinning, moisture supply and amount and type of dormant pruning influence size. Usually, the size of fruit is a greater problem with old trees than with younger trees because of the difference in vigor of the fruiting wood.

Thinning tends to increase the amount and intensity of red over-color as well as the intensity of yellow ground-color of red varieties. Thinning does not influence color so strikingly as it does size, however. Pruning, nitrogen supply, sunlight, and temperature have such a strong influence on color that the effect of thinning may be obscure.

Thinning, when needed, has a definite influence on the dessert quality of apples. The dry matter and sugars increase with an increase in leaf surface per fruit up to a certain point. Acidity also tends to increase, but this is not so marked as the sugar content. This effect of thinning is especially pronounced with such dessert varieties as McIntosh, Delicious, and Northern Spy.

Many varieties of apple trees are subject to severe breakage when carrying a heavy load of fruit, a hazard that is reduced by thinning. Propping is not a substitute for thinning; overloaded limbs often break at or just beyond the point where the prop is placed.

Although thinning usually reduces the total yield, the effect is somewhat more pronounced with late than with early thinning. Such results should be expected, because the practice involves the removal of enough fruits to permit the remainder to benefit from an increased food supply. Unless thinning is overdone or done extremely late, the reduction in total

yield should amount to no more than 10 to 20 percent. When the set is heavy, attention should be focused on obtaining the largest volume of marketable fruit rather than the greatest potential tonnage.

The decrease in the amount of labor required to harvest a well-thinned block of trees as compared with an excessive crop of small-sized fruit is well worth consideration. It is conceivable that the saving in harvesting and handling might offset a large part of the cost of thinning.

Time to thin

The sooner after bloom that thinning is completed, the more favorable will be the results. The drain on food materials is relieved as soon as the excessive fruits are removed. Early thinning is especially important with summer varieties such as Duchess, Transparent, and Early McIntosh. Profits from these varieties depend on good marketable size of a large proportion of the crop at the earliest possible date.

Amount to thin

The idea of establishing a certain ratio between leaf area and fruits is theoretically sound, but it is difficult to apply in practice. Generally, recommendations for thinning are based on the distance between adjacent fruits on the same branch. Fruits should be allowed to hang more closely on vigorous well-exposed wood than on the weaker wood that is usually in the inner and lower parts of the tree. Spacing distances commonly suggested range from six to 10 inches. The 10-inch distance is considered heavy thinning and is advisable only with such varieties as Delicious, Golden Delicious, and Northern Spy, where large size fruits are required for special outlets. On heavily set trees, a spacing distance of from five to eight inches should prove satisfactory under most circumstances, although this would vary with the variety and with environmental conditions.

For such varieties as Milton, McIntosh, Cortland, Delicious, Rhode Island Greening, and Northern Spy, reducing the bearing spurs to one fruit each would probably be enough in most years. On the other hand, Transparent, Lodi, Early McIntosh, Wealthy, Macoun, Baldwin, and Golden Delicious will require greater spacing.

Effect on annual bearing

Heavy setting and biennial bearing are closely associated. For all practical purposes, it can be said that one is the cause and the other the effect. Varieties that characteristically set heavily, such as Transparent, Wealthy, and Baldwin, are recognized as pronounced biennial bearers. While other varieties, such as McIntosh, Cortland, and Rome Beauty,

which are more moderate with respect to fruit set, tend to bear annually. Of course, any variety may become distinctly biennial as the result of a crop failure from frost or from other unfavorable conditions. Also, an extremely heavy set from excessive cross-pollination may initiate alteration by preventing fruit-bud formation.

Hand thinning apples after the June drop has little or no effect in breaking the biennial habit of mature trees. Even though heavy thinning is resorted to, evidence indicates that this practice is performed too late to influence flower-bud formation for the following year. Late thinning may have some accumulative effect in maintaining an annual bearing condition with some varieties.

Although these basic concepts were developed from experiments involving hand thinning, the method has become impracticable for most growers because of costs and the lack of experienced help. For this reason, much attention has been given to the possibility of thinning apples with a chemical spray, a practice that has become widely used in New York orchards.

Chemical thinning

Naphthaleneacetic acid and naphthaleneacetamide, two growth regulators, are the most popular chemicals used for chemical thinning. DN chemicals sold as insecticides have been employed for thinning heavy-setting varieties in New York and are widely used in other areas. Favorable results with DNs depend on a rapid development of bloom and relatively dry weather, but these conditions cannot be depended upon in the Northeast. The outstanding feature of the growth regulators is their post-bloom use, when the set and need for thinning can be appraised. There is also evidence that these chemicals result in more flower bud formation than can be accounted for in the amount of thinning accomplished. For these reasons, naphthaleneacetic acid and naphthaleneacetamide are preferred in the humid areas of the Northeast.

Time of application

Thinning sprays on summer varieties (Red Astrachan, Transparent, Lodi, Duchess) should be made within the seven-day period following full bloom. Later sprays cause premature ripening of the fruit and should be avoided. To minimize leaf injury, naphthaleneacetamide (the amide) is the better choice for early apples.

Fall and winter varieties may be spray thinned any time during the 18-day period following full bloom. This allows time to appraise set, consider weather conditions that may affect results and select a favorable

day for the treatment. Sprays applied closer to the 18-day period appear to be the ones most likely to cause an increase in blossom formation for the following year.

The use of amide on Red Delicious should be limited to the petal fall stage to avoid small seedless fruits (pygmies). If a later date is preferred, naphthaleneacetic acid (NAA) should be used. The use of NAA 14 to 18 days after bloom has given the most consistent results with Golden Delicious and Rome Beauty.

Important points

Many factors influence spray-thinning results. Most favorable responses cannot always be duplicated. Despite this, spray thinning has become an economically sound practice with many orchardists.

Whatever number of trees are sprayed, spray them thoroughly. The top of the trees should be well covered; spray bottoms as needed in crowded plantings.

Do not spray thin trees under 14 to 16 years of age unless they have become biennial in bearing.

Exposure to freezing temperatures (26° F. to 28° F.) or a week or more of cloudy, wet weather before treatment results in maximum absorption of the chemical and greater thinning. Freezing temperatures frequently occur in the low spots leaving foliage of trees on higher ground unaffected. Lower concentrations should be used where foliage is exposed to such adverse weather conditions. A calm, warm day when a maximum temperature of about 75° F. is predicted is considered ideal for the spray.

The most recent information on spray thinning can be obtained from the local county agricultural agent.

MOUSE CONTROL

An annual program for control of mice must be maintained in the orchard. Practices necessary for mouse control are as follows:

Protect trunks of young trees with a wire guard. One-quarter inch wire mesh has proved most satisfactory. Embed the guard at least six inches beneath the soil surface.

Keep the areas within two or three feet of the trunk free of ground cover. The use of herbicides can be helpful. When scraping the soil in the fall, do not expose previously covered bark. This tissue is highly susceptible to winter injury.

A layer of crushed stone or coarse cinders around the base of older trees can discourage mice.

Never allow newly cut prunings to accumulate for any period of time around the base of trees.

Maintain an annual poisoning program. The most effective methods of poisoning can be obtained from the county agricultural agent.

Mice usually girdle the trees during late fall, winter, and early spring when succulent green vegetation is at a minimum. Control operations should be conducted after harvest in early November, before the first snowfall. The orchard should be examined during open periods of winter when snow may be off the ground. If mouse signs are present, control operations should be repeated.

Two species of mice can be troublesome in the orchard. The field mouse is widely distributed throughout New York State. Damage caused by this mouse is most severe at or close to the surface of the ground. The pine mouse, confined to some of the southern areas of the Hudson Valley, burrows more deeply than the field mouse; it is more difficult to control and damage to the tree can be deeper and more severe than from the field mouse.

The best remedy for mouse damage is prevention. If girdling does occur, bridge-grafting can be used to save the trees. Information on procedures in bridge-grafting may be obtained from the fruit agent.

PRUNING

Young bearing trees

Trees that have been trained so the scaffold limbs are well distributed and properly spaced need no large cuts during the early years of bearing. Any cuts that are made should be of the corrective type, such as the removal of suckers and of crossing twigs and the correction of narrow-angled crotches.

Older bearing trees

As trees advance in bearing age, the fruiting wood thickens. Shading begins to reduce the vigor of many twigs and it becomes increasingly difficult to spray and obtain thorough coverage. This condition is corrected by pruning. The amount and kind should be closely related to the yield of marketable fruit, the net return, and maintenance of the bearing area in a desirable location.

Larger cuts first

Make the larger pruning cuts first. This does not mean to cut out the largest limbs one can find. It does mean to remove the smaller or medium-sized limbs adjacent to stronger limbs that can soon fill in the gap and present the appearance of a continuous fruiting area. If smaller cuts are made first, over-pruning may result.

Figure 8. An unpruned (top) and a pruned (bottom) Rhode Island Greening.

Corrective cuts may be necessary. With some varieties, the first scaffold limbs grow horizontally or downwards to such an extent that the bearing surface lies on or near the ground. These limbs should be removed completely. If a number of limbs arise from one area on the trunk, one or two should be removed. This is more rapid and usually more effective than snipping many small cuts.

Removal of larger limbs first is adapted to varieties such as McIntosh, Delicious, Rhode Island Greening, and Baldwin, which bear mainly on spurs.

Twenty Ounce, Cortland, and Rome Beauty often have a few large limbs that can be profitably removed, but they grow much fine wood. Again, remove larger branches that can be spared to relieve a crowded situation. Further detailed pruning is time consuming, but superior in terms of fruit quality. The method selected depends upon economic considerations.

Heading back

With large cuts out of the way, tall trees need heading back in the top. Heading-back cuts should be started before there is a need to cut into wood more than two to 2½ inches in diameter. They should be made to outward growing laterals. Annual or regular heading back and thinning out of the top will help maintain vigorous fruiting wood where spraying and picking operations are most economical.

When closely planted trees crowd in the orchard, two choices (or a combination of the two) are available: remove a certain number of trees, and/or head back the side branches. With air-blast methods of spraying, the hedge-row system is gaining in favor. Here the trees are spaced more closely within than between rows. Higher yields per acre are more possible with the hedge-row system than with more widely spaced trees. Production of good quality fruit is possible with this system only if side limbs are kept headed back and thinned out to avoid excessive shading within the row.

Thinning out

Once the larger and heading-back cuts have been completed, the need for smaller cuts can be more clearly seen. All water suckers and fruiting spurs within three or four feet of the central leader should be removed. Fruiting spurs should be well spaced over the remaining area of the limbs. Water suckers growing straight up into the tree, and weak wood growing from the under-surface of scaffold and secondary limbs, should be removed. The bearing area should be balanced but not crowded on the limbs.

Special problems

Lower limbs of older trees often have long expanses with no effective leaf area except a tuft at the very end. The leaf area in the tuft cannot be effective in fruit production because of the large wood area that needs nourishing. Occasional heading back of side limbs of selected parts of a grower's holding will help avoid tufted limbs. Such heading back cuts do remove large numbers of fruit spurs. Heavy heading back of all of a grower's holdings in any one year should usually be avoided. Remember that it takes three years for a vegetative bud to form a fruit.

Red-banded leaf roller has become a problem in some bearing apple orchards. The problem is usually most severe and originates in the lowest limbs. Eventually control should be in the form of improved materials and methods of application. Until then, heavier-than-normal pruning of lower limbs and removal of limbs on the tree periphery may be needed to facilitate spray penetration.

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